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**Final Report on the**
**Kodak/EPA Technology Transfer Project**

# EPA-Developed Methodologies for Assessing the Fate and Hazards of Industrial Chemicals

## A Summary of Eastman Kodak Company's Experience with Their Use and Applicability in Risk Assessment



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## Executive Summary

Eastman Kodak Company in cooperation with the Chemical Screening and Risk Assessment Division at the USEPA recently completed participation in a technology transfer project aimed at assessing whether EPA-developed screening methodologies could be used by industry to make more informed decisions about the health and ecological risks from industrial chemicals. The project evolved considerably over a two-year period, and as team members gained familiarity with the methods they became increasingly aware of the information that could be obtained when the tools were properly applied and utilized. As a result of Kodak's participation, many of the methods examined during the course of the project have been or will be integrated into a library of existing tools to evaluate the fate and hazards associated with the production and use of industrial chemicals. The technology transfer team found their participation in the project to be a valuable and worthwhile experience that will positively affect how new and existing chemicals and chemical processes are assessed. The team also believes that the results achieved in this project could be achieved by other industries. Many pollution prevention efforts would undoubtedly benefit from the use of the EPA-developed methods if the proper framework can be put in place to apply the methods and interpret the results.

The project is best considered as occurring in three separate stages: i) method acquisition and training, ii) method integration, and iii) case study. The method acquisition and training stage involved a performance evaluation of the methods using a group of five probe chemicals that were independently evaluated by team members from Kodak and the EPA. After obtaining highly consistent and reproducible results in the first stage, the project advanced to the second stage where the EPA methods saw limited integration into field projects that involved product design or reformulation. Again, the methods performed well and provided some new approaches for identifying and eliminating from consideration those chemicals posing the greatest potential for harm or excessive exposure. The third and final stage of the project involved a case study where a larger number of methods were used to establish guidelines for the safe handling, disposal, and

manufacturing of a chemical that had never before been manufactured or commercially synthesized.

Each stage of the technology transfer provided team members with different perspectives and insights into the use and applicability of the methods. The following points summarize some of our most important observations.

1. The screening models were judged to be valuable adjuncts to existing programs when used in conjunction with professional judgment.

2. The methods can have an immediate and positive impact on programs to enhance pollution prevention if the proper management infrastructure and communications framework are in place to take advantage of the results.

3. The tools are perhaps most useful when systematically applied at an early stage of product development where their potential impact is greatest.

The Kodak team was clearly impressed with the usability and adaptability of the EPA-developed methods. Team members continue to look for areas where the methods can be used in a cost-effective manner to minimize or eliminate the risks from industrial chemical production, use, and disposal.

## Overview

Eastman Kodak Company, like many large corporations, embraces Total Quality Environmental Management (TQEM) and is committed both in spirit and in practice to environmental responsibility.[1] The leadership, teamwork, and continuous improvement goals that symbolize a quality commitment have long been at the core of the company's approach to pollution prevention and toxic use reduction. The following report summarizes Kodak's participation in a wide-ranging and in-depth technology transfer project that offered a unique opportunity to improve upon existing procedures for assessing the potential health and environmental effects of industrial chemicals. Over a two-year period, chemists, toxicologists, and engineers from the Health and Environment Laboratories at Kodak (HAEL) met with a team of experts from the Office of Pollution Prevention and Toxics (OPPT) at the USEPA to develop an understanding and appreciation of the methods developed by the Agency to evaluate chemical hazards and exposures. Kodak's participation in the EPA project was consistent with three important administrative doctrines that were ultimately keystones for the project's evolution and success.

1. Kodak's tradition of promoting materials conservation, toxic use reduction, exposure minimization, and pollution prevention during the design and manufacture of photographic products.

2. Kodak's effective use of Corporate Performance Standards to eliminate unsafe and unreliable chemical handling practices from the workplace[2].

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[1] Kodak's TQEM has been described in an article entitled, Kodak's Framework and Assessment Tool for Implementing TQEM , which appeared in the Autumn 1993 edition of *Total Quality Environmental Management*.

[2] Kodak's Corporate Performance Standards are itemized and explained in a paper published in the Winter 93/94 edition of *Total Quality Environmental Management* and in the company's annual report on the environment.

3. The Health and Environment Laboratories' policy of "continuous improvement" for the health and environmental services provided to the research, product development, and manufacturing communities within Kodak.

The technology transfer project between Kodak and EPA was primarily established to assess whether EPA-developed screening methodologies could be used by industry to make more informed decisions about the health and ecological risks from industrial chemicals. From its inception until its conclusion, the project was enthusiastically endorsed by Kodak and EPA management as an important educational opportunity that could add to the number of tools currently available to assess exposure, hazard, and risk. Indeed, overall support for the project grew as the work progressed and the participants became increasingly aware of the new information that resulted when the tools were properly applied and utilized.

Kodak believes that participation in this technology exchange was a valuable and worthwhile experience that will positively affect how the company assesses potential hazards and exposures arising from its manufacturing operations. The team would like to commend the management and staff of the Chemical Screening and Risk Assessment Division (CSRAD) for initiating this project and for their commitment and support during all phases of its completion.

## Introduction

Since its inception, the EPA has devoted considerable resources to the creation of databases that could be used to help assess the hazards and environmental fate of chemicals. Over the years these resources have provided a critical databank that has helped Agency personnel assess the possible hazards associated with the use and environmental release of chemicals that did not have an extensive toxicology testing portfolio. With the implementation of TSCA[3], the Office of Pollution Prevention and Toxics saw a tremendous need for the creation of new predictive techniques that could be used to identify chemicals and chemical processes with the greatest

[3] The Toxic Substances Control Act became law on October 11, 1976.

potential for harming human health and the environment. A variety of screening tools were developed by scientists within the Agency to assist in characterizing the health hazards arising from the manufacture, use, and disposal of new chemicals. These tools included a large number of computer-based methodologies that could be used to either assess the environment fate of a chemical or to predict its intrinsic hazard to plant and animal species. Following validation and refinement, these tools became a part of EPA's toolbox for assessing the toxicological and ecological impact of a chemical and for preventing illness and pollution.

Bolstered by years of experience and everyday use, the methods were viewed as an important resource that could also be useful to non-Agency scientists involved in assessing chemical hazards, exposures, and risks. Identification, distribution and technical support of the methods became an important initiative within the Agency. As part of its Pollution Prevention Program, the EPA searched for a partner willing to participate in a technology exchange project that could be used to assess their overall utility to industry. Viable field use of the methods by a small group of volunteer companies was essential if wider distribution was to occur. Ultimately, it was anticipated that industries or consulting operations with the requisite interest and infrastructure could develop their own processes for integrating, conducting, and operating the methods within their own health and environmental programs. Interested companies were asked to participate in the program and independently examine the tools in their current state of development[4]. Kodak agreed to participate in the project after it was determined that the methods could supplement current techniques and assist research and product development scientists by providing an early assessment of the potential health and environmental effects of raw materials slated for use in new and existing product designs.

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[4] Officials from the USEPA met with member companies from the Chemical Manufacturers Association and the Synthetic Organic Chemicals Manufacturing Association to solicit a partner in the project.

The Kodak\EPA technology transfer project began with the preparation of a modest workplan that outlined the procedures, events, and personnel needed for an effective exchange of information on a limited number of methods. Both organizations assembled teams of project participants who became involved with all phases of the project plan and who closely cooperated on the information exchange that accompanied the technology transfer[5]. Kodak participants were selected on the basis of their familiarity with hazard and exposure assessment techniques, their knowledge of design and manufacturing operations, and their experience with evaluating health and environmental information. A conscious attempt was also made at the start of the project to involve an active participant from the synthetic or R&D design community who was not on the environmental staff and who could provide a client's perspective on the use and value of the methods. The initial scope of the project grew as the project unfolded, and progressed from a structured examination of the operational attributes for the various methods to an appraisal of their actual performance with new and on-going product designs. Although access was provided directly and indirectly to the EPA-developed screening methods at various times during the project, only a selected number were acquired and assimilated to an appreciable extent. Resources were deliberately focused on those methods that could have the greatest impact at the earliest stages of product development. It was recognized from the outset that the successful application and integration of the information from the methods would be highly dependent on an organizational structure that allowed for rapid and reliable data incorporation. Existing lines of communication between company health and environmental scientists and product development chemists were not, however, altered for the purposes of this project.

The Kodak/EPA technology exchange program proceeded through several distinct phases as work progressed. Each phase produced progressively higher levels of understanding for the

[5] The project participants from Kodak and the EPA are identified in Appendix A.

ability of the methods to provide useful and highly applicable information. The Kodak team was particularly interested in the ease of use of the methods and their ready adaptability to the highly driven atmosphere that can accompany new product design and reformulation. For the purpose of this report, the phases of the project have been arbitrarily divided into three distinct stages, each having slightly different interim goals and eventual outcomes. Each stage is briefly outlined below and then described further in the following sections of the report.

**Stage 1. Method Acquisition and Training**

Five chemicals were selected as investigative probes to ensure adequate instruction on the proper use and operation of the methods. A written profile describing the chemical structure, physical form, manufacturing process, and final intended use of each chemical accompanied the probe chemical selection process. Using the information contained in the chemical profile, the health and environmental hazards of each probe chemical were independently and simultaneously assessed by personnel from Kodak and the EPA. A comparison of the hazard and exposure findings obtained by each team showed highly consistent and reproducible results for the health hazard and environmental effect assessments. Fifteen different health and environmental endpoints ranging from mutagenicity and oncogenicity to treatment plant release were evaluated[6], and agreement was obtained on all but a single comparison with one of the five probe chemicals. These findings provided some very encouraging news and prompted an expanded analysis that included some elements of risk determination.

**Stage 2. Method Integration**

The second phase of the project overlapped considerably with the first as some team members began to see the immediate impact that the methods could have on ongoing programs. There was no detailed planning or strategic initiative that signaled the start of this phase. Instead, a

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[6] The fifteen endpoints examined for each probe chemical were: mutagenicity, oncogenicity, reproductive toxicity, acute toxicity, subchronic and chronic mammalian toxicity, neurotoxicity, biodegradation, fish $LC_{50}$, daphnid $EC_{50}$, algal $EC_{50}$, chronic fish toxicity, chronic daphnid toxicity, dermal uptake, inhalation uptake, and octanol/water partition coefficient.

small number of methods were integrated into the chemical evaluation process that normally accompanies the design or reformulation of a new or existing product. At first, a limited number of well-documented and well-described methods were examined under field conditions that were highly circumscribed. This changed with time, however, and more methods came to be used in a wider variety of functions and under less stringent conditions.

A good example of the method integration process from this stage of the project involved a design program aimed at reformulating a photographic solution used to process black and white film. Prior to any detailed product testing, a large group of chemicals with the desired commercial properties was identified as potential substitutes in the formulation. The candidate chemicals were screened for possible environmental effects using the ECOSAR program and the physical property methods identified by the Agency. The toxicity and fate estimates provided by these methods were used together with established in-house evaluation procedures to reduce the list of potential substitutes to those exhibiting the lowest threat to the environment. The methodologies supplied by the Agency allowed those chemicals with the greatest potential hazard to be eliminated from further consideration at a point in time when the economic impact of the decision was minimal. By applying the methods early in the development cycle, Kodak was able to avoid unnecessary expenditures on product formulations where appropriate alternatives were available or could be developed.

**Stage 3. Case Study**

Based on the results from the second phase, the project proceeded to a third phase where a larger number of methods were used to make decisions regarding handling, disposal, and manufacturing for a chemical. Team experience at this point in the project indicated that the methods might be particularly useful when used to minimize the generation of hazardous wastes and by-products at a point in time when the production techniques were still being formulated. Efforts were therefore concentrated on assimilating those methods that could provide the most benefit for improving the design of new chemicals and products. Predictions of the potential hazards and exposures resulting from the development of a new chemical would help specialists identify the safest and most environmentally sound alternatives for further consideration.

The third phase of the project involved a case analysis where some highly rigorous demands were made of the methods. The EPA methods were used to supplement existing procedures adopted by Kodak's Chemical Evaluation Team. A detailed examination of potential occupational and environmental exposures was conducted for a synthetic chemical that was in a rather advanced state of development. Fate, hazard, and exposure models were all utilized to: i) map the movement of the chemical in various waste streams, ii) predict the levels that would occur at various stages of synthesis, isolation, and solvent recycling, and iii) establish guidelines for safe handling and disposal of the chemical. The methods performed admirably during the case study and earned recognition as important tools for future use.

## Method Acquisition and Training

The screening methods provided to Kodak by the EPA included procedures for assessing the hazards and exposures resulting from the occupational use, commercial introduction, and environmental release of a chemical or chemical mixture. No attempt was made by the Agency to embellish the performance characteristics of the methods or to alter the user friendliness of the software. All were provided in their exact form with the supporting documentation that was typically available. The EPA-developed models were provided to Kodak in several different forms, each carrying its own unique set of functional characteristics and operational requirements.

The technology transfer teams assembled by EPA and Kodak interacted on many levels during the course of the exchange to ensure proper training in the operation and use of the methods and to discuss the pitfalls that could cause misinterpretation of the data. Group training sessions and conference calls were particularly useful and helped fill many of the gaps caused by incomplete or nonexistent instruction manuals. Direct discussions between EPA experts and specialized subgroups allowed the team participants to become more fully aware of the overall capabilities and limitations of the different models. Individual correspondence and communication also occurred at various times during the project when assistance was needed to resolve an apparent ambiguity in the operation or use of a particular method.

Approximately twenty different methods were presented and discussed at the EPA training session held early in the project[7]. As the training period progressed, attention was focused on acquiring the skills needed to use a limited number of procedures and techniques. This allowed the team to concentrate its time and resources on those techniques that held the greatest promise of fulfilling company needs. Methods presented at the training session were made available on request for the purposes of this project or were purchased from designated vendors. A package of physical property estimation programs used routinely by the Agency was only available by direct purchase from the Syracuse Research Corporation (Syracuse, NY). Some computer hardware was also purchased to increase the performance of several software programs[8], but for the most part the methods were easily installed and operated using standard 386 personal computers.

Perhaps the single most challenging portion of the training period involved the use of a Structure Activity Team (SAT) to evaluate potential health effects from a chemical. The SAT at the EPA is composed of experts from ten different disciplines who are responsible for rendering an opinion based on: i) the physical and chemical properties of a chemical, ii) toxicological information for structurally similar compounds, and iii) professional judgment. Because there is an element of subjectivity in their deliberations, the effectiveness and consistency of an SAT are highly dependent on the training and experience of each member.

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[7] The methods are listed in Table 1 and the acronyms are described in Appendix B.

[8] A math co-processor was purchased for about $300 and installed on the personal computer being used to run all of the programs except CLogP, which was available on a VAX computer.

Prior to the initiation of the joint project, Kodak already possessed an internal body of experts who were members of a Chemical Evaluation Team (CET) that functioned much like the EPA SAT[9]. Some members from Kodak's CET also participated in the technology transfer program, which proved to be a very important factor that minimized the complexity of the interchange and maximized the opportunity for an effective exchange of information. The existence of a CET within Kodak also freed the team members from many logistical concerns and allowed the communications to focus on organizational and procedural differences between the two expert committees. Subsequent comparison of the qualitative evaluations performed by Kodak and EPA, using ground rules established by the SAT, showed highly consistent results for a set of probe chemicals. These results indicated that the training was a success and that the two teams could arrive at similar conclusions despite different backgrounds[10] and supporting databases[11].

In general, the training and acquisition phase of the project proceeded smoothly considering the large amount of information that was transferred and assimilated. Very little software troubleshooting was necessary and the group found only a few gray areas in need of refinement and resolution. Many of the techniques, especially the computer-based estimation routines, were judged to be well within the grasp of most companies with a minimum amount of training needed prior to use. A few techniques, however, were found to be more complex

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[9] Details concerning the function and operation of the CET can be found in an article entitled, Sequential Testing for Chemical Risk Assessment . In: *Environmental Risk Analysis for Chemicals*, R.A. Conway, ed., Chpt 12, pp. 412-433, 1985. Van Nostrand Reinhold Co, New York, NY.

[10] While the skills and experience levels of the EPA SAT and Kodak CET were similar, no attempt was made to adjust the participant levels in either team to match the other.

[11] Some of the databases available to the EPA SAT included confidential business information that was not made available to Kodak. Kodak databases included commercial proprietary information that was not made available to the EPA.

and possibly outside the reach of many small to medium-sized companies because the required level of expertise and professional competence may not be available. These latter techniques included the use of expert panels whose members needed to possess extensive training, experience, and education. Despite the complexity, there may be an opportunity for consulting groups to provide a value-added service to small and medium-sized companies when appropriate expertise is not available internally.

The following table presents some of the more salient characteristics of the methods made available to Kodak by the EPA. In addition to providing information on the source and intended use of the methods, Table 1 provides an estimate of the overall complexity and utility of each method as judged by members of the Kodak project team. The assessment is not intended to be a highly rigorous evaluation of each method's usefulness, but instead represents the impressions of the reviewers during early stages of use. Evaluators from other institutions would undoubtedly have different opinions and conclusions based on their own unique situations and specific needs.

**TABLE 1**

| Method[1,2] | Target & Endpoint | Source (Cost)[3] | Complexity | Overall Utility |
|---|---|---|---|---|
| Exams II | Environ. - Exposure | EPA | High | Medium |
| Inhalation* | Health - Exposure | EPA | Medium | High |
| OncoLogic® | Health - Hazard | Not Released[4] | Medium | ------- |
| PDM* | Environ. - Exposure | EPA | Low | High |
| TBase | Health - Exposure | EPA | Medium | High |
| CLogP* | Environ. - Exposure | MedChem (>$1K) | Low | High |
| ECOSAR* | Environ. - Hazard | EPA | Medium | High |
| SAT* | Health - Hazard | ------- | High | High |
| BIODEG* | Environ. - Exposure | SRC ($400)[5] | Medium | High |
| Kow* | Environ. - Exposure | SRC ($600)[5] | Low | High |
| AOP | Environ. - Exposure | SRC ($450)[5] | Low | Low |
| Henry* | Environ. - Exposure | SRC ($400)[5] | Low | Medium |
| Hydro | Environ. - Exposure | SRC ($400)[5] | Low | Low |
| Koc | Environ. - Exposure | SRC ($400)5 | Low | Low |
| STP* | Environ. - Exposure | SRC ($250)[5] | Low | High |
| FGETS | Environ. - Exposure | EPA | High | Low |
| Dermal* | Health - Exposure | EPA | Low | Medium |
| SESOIL | Environ. - Exposure | RiskPro ($900) | Medium | Low |
| ATOCHEM | Environ. - Exposure | Unavailable | ------ | ------ |
| PTPLU | Environ. - Exposure | EPA | Low | Low |
| SCIES | Health - Exposure | EPA | High | Medium |

[1] The methods listed in this Table were identified at some point during the technology transfer project; however, only those marked with an asterisk (*) were used to an appreciable extent during the course of the project.

[2] The methods are further identified in Appendix B.

[3] The cost of commercially available programs is shown in parenthesis ( ). The EPA programs were provided on request.

[4] The OncoLogic® program was not available at the time this project was initiated; however, it is now available from LogiChem Inc. (Stroudsburg, PA).

[5] These seven methods can be purchased as a package from Syracuse Research Corporation (Syracuse, NY).

## Method Integration

An important operational requirement for the successful use of the EPA methods is the existence of an organizational structure that provides an effective means of incorporating the data into the decision-making process. There are several targets of opportunity for inserting the methodologies into a research and product development cycle. These targets are depicted below in the form of a flowchart that shows four distinct stages beginning with concept development and ending with marketplace presence. Although the methods presented by the EPA could have utility on a broad range of fronts in the cycle, the concept development stage was judged by the project team to be the best site for insertion and management of potential health and environmental effects. Some methods provided by the Agency may be better suited for use at later stages when manufacturing is about to commence or a product line is expanded.

| | | | |
|---|---|---|---|
| Concept Development | Technology Development | Product Development | Marketplace Presence |

For the purpose of this project, however, use of the methods early in the technology development phase of a new product was deemed to be the most cost-effective manner for assessing health and environmental hazards. In order to realize the benefits from early use of the EPA-developed methods, however, a mechanism is needed to incorporate the findings into the chemical design and development cycle without burdening cost or productivity. The incorporation of health and environmental concerns at the earliest stages of design can only be accomplished if management understands and appreciates the advantages offered by the early assessment of potential hazards. Equally important is the ability of the environmental liaison to provide information quickly to the product development teams with a very short turnaround time. The development of "rapid response teams" is an important first step in the use of these methods, since it can provide a home for the methodologies and a gateway for their use in new product development.

The overall capabilities and utility of the methodologies is perhaps not the greatest challenge associated with their use. Psychological, organizational, and cultural factors may prove to be more of an obstacle to implementation of the methods in some situations. These factors can be overcome, however, if a pollution prevention mindset can be created within an organization. Fortunately, there were no barriers within Kodak to the actual application of these methods by members of the project team. Although field use and evaluation of the methods was not one of the original goals of the technology transfer project, several opportunities arose for the team to apply the methods well beyond the initial scope of the project. Using the software systems and technical knowledge transferred during the training phase, several process and product evaluations were performed on R&D projects that were outside the scope of the technology transfer project. Because the project team did not have the opportunity to fully examine all of the available EPA methods, the team did not thoroughly examine all potential applications. The team could see, however, that the methods could be incorporated into a wider variety of design programs and that they could have a positive impact on programs aimed at incorporating pollution prevention principles in a broad range of new products. Kodak's limited experience with the methods thus far has been very positive, and we continue to look for areas where the methods can be used in a cost-effective manner to minimize or eliminate the risks from industrial chemical production, use, and disposal.

## Case Study

Although the specific nature of the R&D programs where the EPA methods were applied is proprietary, some information about the programs can be shared that highlights the usefulness and adaptability of the methods. One program in particular was significantly affected by the availability of the methods. This program involved an evaluation of an intermediate in the synthesis of a chemical that was being designed as a new coupler for use in photographic film. Evaluation of the potential health and environmental effects of this intermediate happened to coincide with the completion of the Kodak/EPA technology transfer project. The overlap thereby provided an excellent opportunity to assess whether the EPA methods could provide new opportunities to make more informed decisions about the health and ecological risks of new chemical production and use.

The chemical being evaluated was a hydrazine derivative that was slated for use as a site-limited intermediate; potential occupational exposures during the manufacturing operations were therefore a concern. Employees involved in the synthesis were expected to handle the material in various operations that ranged in duration from minutes to hours. Several potential health hazards were identified early in the assessment after comparison with similar compounds that had undergone detailed toxicity testing and after detailed structural review using an SAT approach. Estimates of employee exposure were performed using the inhalation and dermal exposure procedures provided during the technology transfer. These methods resulted in the implementation of protective
equipment guidelines to eliminate any potential for occupational exposure. These guidelines included the use of impervious gloves, protective clothing, and respirators of a specific type and dimension.

Environmental hazard and exposure estimations were also performed in conjunction with the health analysis using the tools provided by the EPA. Removal estimation tools and stream flow dilution models provided by the Agency were used to determine the in-stream concentrations that could result when the reactors used for synthesis were cleaned at the end of a batch preparation. The models allowed the simulation of various release scenarios so that a full range of potential waste water conditions could be evaluated. A model used to quantitatively estimate the biodegradation potential of the chemical demonstrated that biological decomposition was the primary route of removal from waste water.

Use of the EPA-developed methodologies aided in the development of a more complete health and environmental assessment and provided a better understanding of the environmental effects for the new chemical and the feedstocks used in the synthesis. The methods were also instrumental in arriving at final manufacturing and use guidelines for the new substitute. A key feature of the assessment included the determination of a "concern concentration" for the receiving body of water[12]. River flow data at the manufacturing site were then used to calculate a release quantity that would not result in stream concentrations above this value. This quantity was used as a guidance value to instruct manufacturing personnel on the containment and cleanup procedures that would be essential for environmental protection. The methods also showed that a significant percentage of the chemical that was expected in the waste water stream would be removed through bacterial processes, but the amount released was still of concern. All waste solvents generated during the synthesis were therefore recycled, and the residue from the solvent distillation was incinerated. The methods thereby directed the team to those procedures needed to prevent environmental release of the intermediate during normal operations.

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[12] A concern concentration of 1 g/L was identified for algae using the ECOSAR program together with a risk assessment paradigm provided by the EPA and described in a paper entitled, Environmental Hazard and Risk Assessment Under the United States Toxic Substances Control Act , *Science of the Total Environment*, Vol. 109/110 pp. 649-665, 1991.

## Summary and Recommendations

When used in conjunction with professional judgment, estimation models were judged to be valuable adjuncts that can have an immediate and positive impact on programs to enhance pollution prevention practices. Opportunities for the successful application of the methods can be enhanced if the proper management infrastructure and communications framework are in place to take advantage of the results. Small to medium-size companies may not have the resources in place to rapidly transfer some of the methods; however, a sizable number are relatively easy to use and can be rapidly incorporated into a variety of pollution prevention efforts. The tools are perhaps most useful when systematically applied at an early stage of product development. Many of the methods examined in detail during the course of this project have become permanent additions to our library of methods for evaluating the fate and hazards of new and existing chemicals. Additional methods will undoubtedly acquire the same status as Kodak gains experience with the methods that have greater applicability in the latter stages of the product development cycle.

Participation in this project has given the Kodak team a unique perspective to evaluate and comment on the use and applicability of the methods in an industrial setting. Although the methods were found to have practical value, there are several actions that the Agency could take to further increase their accessibility and adaptability. These actions include:

1. Broader dissemination and promotion of the methods to industrial groups and organizations that may not be aware of their existence, but could benefit from their availability and use in any of a variety of pollution prevention initiatives.

2. Development of a decision framework that could guide new users and provide a more systematic approach for applying the methods in any of a variety of pollution prevention scenarios.

3. Continued work on the development of new quantitative methods, especially in the area of human hazard assessment, which currently relies too heavily on the use of expert judgment teams.

## Appendix A

### I. Eastman Kodak Company

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## Appendix B

Models and procedures discussed in conjunction with the Kodak\EPA technology transfer project.

1. **Exams II** - Environmental Exposure and Analysis Modeling System
2. **Inhalation** - Human Uptake by the Inhalation Route
3. **OncoLogic®** - Cancer Hazard Expert System
4. **PDM** - Stream Probabilistic Dilution Model
5. **TBase** - Third Base Consumer Exposure Evaluation Program
6. **CLogP** - Octanol/Water Partition Coefficient
7. **ECOSAR** - Ecological Structure Activity Relationships
8. **SAT** - Structure Activity Team
9. **BIODEG** - Estimated Aqueous Biodegradation Rates
10. **Kow** - Estimated Octanol/Water Partition Coefficients
11. **AOP** - Atmospheric Oxidation Program
12. **Henry** - Henry's Law Constant Program
13. **Hydro** - Estimated Aqueous Hydrolysis Rates
14. **Koc** - Estimated Soil Sorption Coefficients
15. **STP** - Sewage Treatment Plant Model
16. **FGETS** - Food and Gill Exchange of Toxic Substances
17. **Dermal** - Human Uptake by the Dermal Route
18. **SESOIL** - Seasonal Soil Compartment Model
19. **ATOCHEM** - Automated Chemical Property Estimation System
20. **PTPLU** - Atmospheric Point Plume Dispersion Model
21. **SCIES** - Screening Consumers Inhalation Exposure Software